Center Independent Research & Development: JPL IRAD

Cryogenic Active Mirrors (CAM)

Completed Technology Project (2015 - 2016)

Project Introduction

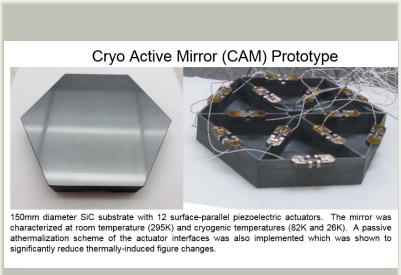
This effort seeks to develop active mirrors that can correct for thermally-induced figure deformations upon cooling from room-temperature at the time of manufacture, down to cryogenic temperatures (4K) during operation. To do so, an array of piezoelectric actuators are distributed across the backside of a lightweighted silicon carbide substrate in a surface-parallel fashion. Each actuator can "push" or "pull" on the surface through the application of an electric field. This actuation scheme has been performed for room temperature mirrors, however it has yet to be demonstrated at cryogenic temperatures. This is the primary focus of the current effort.

The primary goal of the Cryogenic Active Mirror (CAM) technology development effort was to demonstrate comparable active figure control at room and cryogenic temperatures. This was performed experimentally by constructing a small-scale demonstrator mirror and subjecting it to cryogenic temperatures in a thermal-vacuum chamber. This test provided a comparison of actuation stroke and figure correctability at both temperatures. The second objective of this effort was to establish a point design for a 4x6m active aperture for a notional Far-IR telescope This was performed using a finite element model (FEM), along with results from the experimental campaign. In doing so, predictions on mirror stiffness, mass, and ability to correct for gravity sag and thermal deformations was established. Finally, the last objective was to explore new methods of actuation that require zero voltage to maintain their specific actuation state. This was performed by material characterization of piezoelectric materials at reduced temperatures.

Anticipated Benefits

Cryogenic Active Mirrors, with the capability of correcting thermal deformations incurred during cool-down from 293K to <30K, offer potentially large cost savings for a Far IR Surveyor mission, by reducing or even eliminating cryo testing during mirror fab and/or system I&T. They offer mission risk reduction, by enabling correction of nearly any optical error after launch. Further cost savings will come from relaxed system fabrication and assembly tolerances, speeding up system I&T, and reduced mirror mass and cost compared to passive mirrors.

This technology can be directly applied to Earth-observing telescopes operating at reduced temperatures, which is potentially of interest to non-NASA agencies.



150 mm diameter SiC substrate with 12 surface-parallel piezoelectric actuators.

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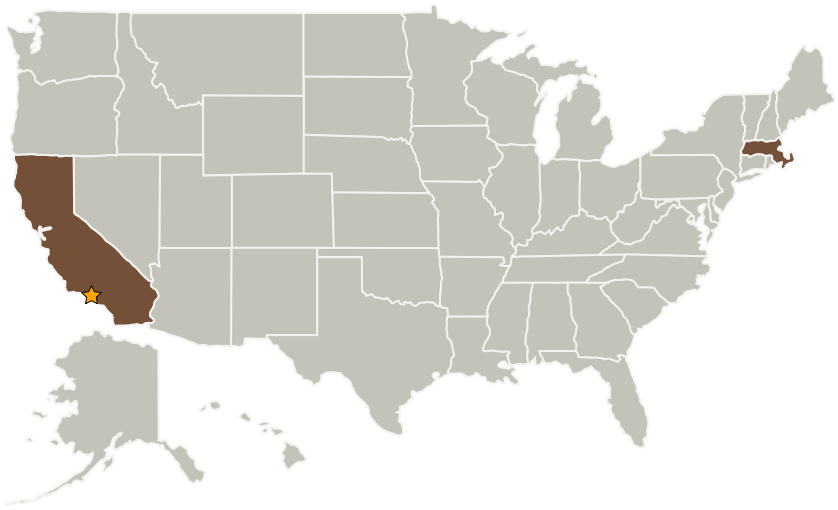
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
AOA Xinetics	Supporting Organization	Industry	
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations	
California	Massachusetts

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Center Independent Research & Development: JPL IRAD

Project Management

Program Manager:

Fred Y Hadaegh

Project Manager:

Fred Y Hadaegh

Principal Investigator:

David C Redding

Co-Investigators:

Jeffrey Cavaco
Dennis Kochmann
Christopher G Paine
John B Steeves
John Vayda

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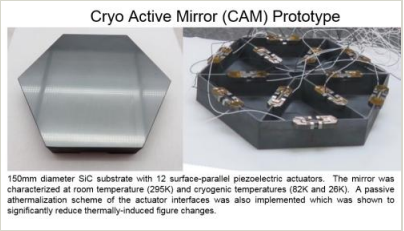
Images

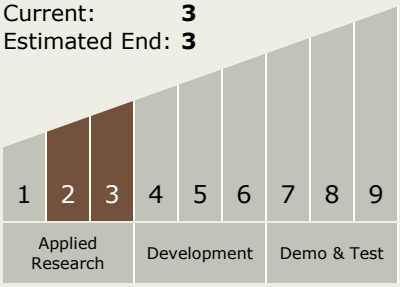


Cryo Active Mirror (CAM) Prototype Image
150 mm diameter SiC substrate with 12 surface-parallel piezoelectric actuators.
(https://techport.nasa.gov/image/24468)

Cryogenic Active Mirrors Poster by David Redding
(https://techport.nasa.gov/image/)

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.1 Mirror Systems